Heart Surgery Forum 2024; 27(9): E998–E1002
doi: 10.59958/hsf.7905

Case Report

Distinct Roles of Omental and Latissimus Dorsi Flaps for Blocking Infection Pathways and Protecting A Left Ventricular Assist Device

Dongkyung Seo[1], Taku Maeda[1,*], Tomonori Ooka[2], Takahiro Miura[1], Kosuke Ishikawa[1], Emi Funayama[1], Satoru Wakasa[2], Yuhei Yamamoto[1]

[1]Department of Plastic and Reconstructive Surgery, Faculty of Medicine and Graduate School of Medicine, Hokkaido University, 060-8638 Sapporo, Japan

[2]Department of Cardiovascular and Thoracic Surgery, Faculty of Medicine and Graduate School of Medicine, Hokkaido University, 060-8638 Sapporo, Japan

*Correspondence: takumaeda1105@yellow.plala.or.jp (Taku Maeda)

Submitted: 17 July 2024 Revised: 18 August 2024 Accepted: 21 August 2024 Published: 10 September 2024

Abstract

Left ventricular assist devices (LVADs) are vital for managing severe heart failure in transplant-ineligible patients, but device exposure and infection pose significant challenges. This report details a 42-year-old man with dilated cardiomyopathy and bronchial asthma who presented with an externalized LVAD following a HeartMate II to HeartMate III exchange due to malfunction. Our tailored surgical strategy treated the LVAD driveline and main body as two distinct parts. This distinction is crucial, as major upstream infections typically originate from the driveline. We applied flaps to these parts for different purposes, maximizing their unique characteristics. The omental flap, chosen for its flexibility, blood supply, and immunological activation upon foreign body contact, covered the driveline. The latissimus dorsi flap provided vascularity and mechanical protection for the LVAD. Additionally, we review the omentum's basic physiological aspects, which are often unfamiliar to clinicians. Infection has not recurred in 6 months postoperatively, demonstrating the approach's effectiveness.

Keywords

omentum; LVAD; exposure

Introduction

Heart transplantation has long been considered the definitive treatment for end-stage heart failure, offering longer life expectancy and improved functional status to patients with severe cardiac dysfunction [1]. However, the scarcity of donor organs and contraindications in many patients necessitate alternative management strategies. In this context, left ventricular assist devices (LVADs) have evolved not only as a bridge to transplantation but also as a destination therapy for patients who are not candidates for heart transplantation [2].

LVADs effectively provide hemodynamic support and prolong survival but are associated with significant complications. Complications can be roughly categorized into LVAD-specific problems, such as suction events, pump thrombosis and its complications, and LVAD-associated complications, including bleeding, cerebrovascular events, dysrhythmia, and aortic regurgitation [3]. Among these, infection is one of the most common complications, posing substantial management challenges and impacting patient outcomes [4]. Once an LVAD becomes exposed due to surgical or wound-related complications, a comprehensive, multidisciplinary approach becomes essential to manage the device and associated infections effectively. Although the definitive treatment for infection of a prosthetic material is its removal, lifesaving devices cannot be easily removed, so strategies like local wound disinfectant dressings, surgical debridement and antibiotics, relocation or reimplantation, and recently, negative pressure wound therapy (NPWT), are used and have shown improved outcomes [5–7].

In this report, we describe our experience in a case of LVAD exposure, emphasizing the distinct strategy taken to address this serious complication. This case underscores the importance of distinguishing between different parts of the LVAD in surgical planning and enhances our current understanding of activation of the omentum and its clinical significance.

Case Presentation

A 42-year-old man with a longstanding history of dilated cardiomyopathy, which he had lived with for over two decades, presented to our plastic surgery department due to the externalization of his LVAD while awaiting heart transplantation. His medical history included bronchial asthma, but he had no other systemic diseases.

Four years prior to his initial visit to our department, a HeartMate II LVAD had been implanted. Approximately 3 years and 10 months post-implantation, a suspected malfunction in the power delivery line had made it necessary to exchange the HeartMate II for a HeartMate III. Due to differences in the dimensions of the devices, modification of the thoracic cage was required, which included coverage of the device with a Gore-Tex sheet, resection of the 6th and 7th ribs, and application of a rib fixation plate. Two weeks after insertion of the new device, a serous fluid accumulation was noted beneath the surgical site, resulting in wound dehiscence. Reopening and drainage were performed, followed by application of an NPWT system (SNaP™, Spiracur, Inc., Sunnyvale, CA, USA) for 1 month. Although the wound had initially closed, exposure of the rib fixation plate occurred 3 months later. The wound was debrided and the LVAD repositioned. Despite these interventions, wound dehiscence recurred, necessitating reapplication of the NPWT system (SNaP). Cultures from the wound yielded Candida albicans, prompting the initiation of NPWT with instillation and dwell (NPWTid; V.A.C. ULTA™ Therapy System, KCI USA, Inc., San Antonio, TX, USA) 3 times a week on a sterile operation field alongside antifungal therapy. After 1 month of conservative treatment, the wound showed no signs of improvement, and he was referred to our plastic and reconstructive surgery department.

On initial examination, the wound margins appeared indurated, with the Gore-Tex sheet covering the LVAD visibly exposed and the surrounding skin notably pigmented (Fig. 1). During the evaluation and planning phase by the plastic and reconstructive surgery department, NPWTid was continued until the day of the operation, resulting in a total application period of 11 weeks, but this resulted in no improvement. A CT (computed tomography) scan revealed an abnormal fluid collection around the LVAD pocket, suggestive of infection and hematoma formation, and improvement had been noted on monthly follow-ups, and no density changes or abnormal fluid collection around the driveline. EKG (electrocardiogram) revealed a regular sinus rhythm with normal heart rate, P waves, QRS complexes, T waves, and PR intervals, and no significant ST-segment changes or abnormalities in all leads. The postoperative echocardiogram for the LVAD showed increased peak velocity at the inflow cannula, as well as mild diffuse hypokinesis of the left and right ventricles. The aortic valve opened fully with no regurgitation, and there was mild mitral regurgitation. Tricuspid annuloplasty showed trivial regurgitation without stenosis, and mild pericardial adhesion was noted. Laboratory findings revealed mild leukocytosis and mild elevation of C-reactive protein.

A surgical incision was made around the discolored and indurated skin tissue. Then, the Gore-Tex sheet and deteriorated soft tissues were completely excised. The debridement resulted in a soft tissue defect measuring approximately 16 × 5.5 cm. A pedicled omental flap and a pedicled latissimus dorsi (LD) flap were elevated to prepare for reconstruction. The omental flap was raised through a median laparotomy incision and was used to cover the driveline (Fig. 2). The musculocutaneous LD flap was used to cover the LVAD and the skin defect. The donor site of the LD flap was closed using a split-thickness skin graft. The patient has been under observation for 6 months postoperatively and has shown no signs of recurrent infection around the device (Fig. 3).

Fig. 1. Clinical status of a patient with left ventricular assist device exposure at initial examination in our department. The wound has dehisced, exposing the underlying Gore-Tex sheet. The surrounding skin is discolored and firm.

Discussion

Historically, well-known flaps for chest wall reconstruction include pectoralis major, rectus abdominis, latissimus dorsi, and greater omentum flaps. The pectoralis major flap reliably covers the midline to the ipsilateral anterior upper chest with a dependable pedicle. Significant muscle atrophy can occur if the medial pectoral nerve is not restored [8]. The rectus abdominis flap provides a wide range of an-

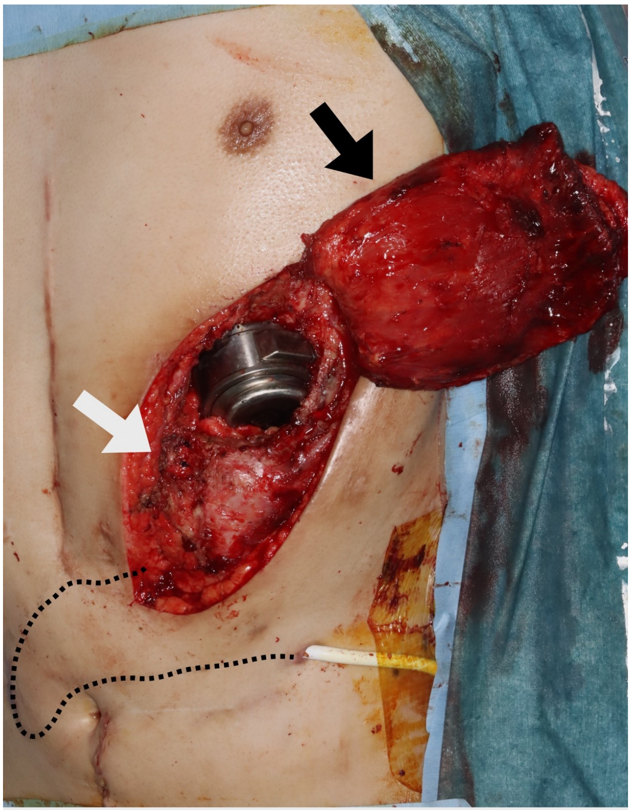

Fig. 2. Positioning of the flaps. The greater omentum is raised through a median laparotomy incision below the umbilicus and positioned through a subcutaneous tunnel to cover the driveline. White arrow: Omental flap. Black arrow: Latissimus dorsi flap. Dashed line: Driveline.

Fig. 3. Clinical status at 6 months postoperatively. No signs of recurrent infection are evident, either on the device itself or along the driveline.

terior chest coverage and includes a large skin island [9]. The latissimus dorsi flap is effective for covering anterolateral to posterior defects [10]. These muscular or myocutaneous flaps can lose volume depending on the proportion of muscle fiber type, innervation, and blood supply [8]. The greater omentum, a visceral adipose tissue flap, is also historically well-known for its immunological function and is widely used for infection control [11].

The management of LVAD infections presents a significant clinical challenge, as infections often originate from the driveline site and can ascend to involve the entire device system [12]. In our case, strategic surgical interventions using specific tissue flaps were critical in managing both the device and its driveline, addressing the distinct challenges posed by each component. Our approach focused on employing specific flaps with a deep understanding of their characteristics to address both the mechanical and biological vulnerabilities associated with LVAD implantation. The decision to use an omental flap for the driveline and a musculocutaneous LD flap for covering the LVAD itself was guided by an understanding of the distinct challenges presented by each component and the unique properties of these tissues.

The gross characteristics of the omentum, particularly its pliability and thinness, make it an ideal choice for obliterating complicated spaces or covering prostheses [11]. Its abundant blood supply is crucial, as it facilitates the robust delivery of nutrients and immune cells to the site, which is essential for enhancing the healing process and controlling infections [4]. Moreover, the greater omentum is known to become activated upon foreign body exposure. This activation results in significant increases, up to 20-fold, in size and weight. Histologically, the proportion of cellular components in the omentum becomes more prominent, and the number of milky spots increases [13]. The activated omentum is richer in cytokines, facilitating the differentiation of mesenchymal stem cells and various growth factors. These biological changes enhance the immunological functions of the omentum, making it pivotal in defending against infections [13].

In this case, the omental flap was selected for its ability to effectively seal spaces around the driveline, minimizing gaps that could potentially harbor infections. This sealing effect is further enhanced by its expected gross and immunological activation, which would significantly increase its biological potential both anatomically and molecularly.

Basic research in animal models has demonstrated that the activity of the activated omentum lasts for several weeks. This is particularly pertinent, as Sivaratnam and Duggan [14] have highlighted, given that the critical period for the upstream dissemination of infection typically occurs between 2 to 6 weeks postoperatively. This timing underscores the omentum's capacity to provide a comprehensive dual mechanism of protection during this vulnerable period.

For LVAD coverage, the musculocutaneous LD flap was selected because it provides the superior perfusion characteristics of muscle tissue compared with fasciocutaneous flaps [15]. While critical evidence directly comparing these types of flaps is lacking, muscle flaps are generally considered more effective for obliteration of dead space, enhancing infection control, and improving perfusion [16]. Additionally, the bulkiness of the LD flap provides substantial physical protection for the LVAD. This cushioning not only shields the device from mechanical exposure and damage but also maintains structural integrity, which is crucial for long-term device support. In this particular case, a pedicled LD flap was used, preserving the thoracodorsal artery and nerve. This technique is expected to minimize muscle atrophy to maintain flap volume and functionality, thereby enhancing the protective and therapeutic benefits of the flap over time [8].

These strategic choices reflect a deep integration of anatomical, physiological, and immunological considerations into the surgical management of complex LVAD complications.

Conclusion

This case highlighted the importance of specialized surgical interventions in the management of an exposed LVAD, with distinct strategies employed for the driveline and the LVAD itself. Using different flaps for each part effectively addressed their unique mechanical and biological challenges, based on the specific biological characteristics of each flap rather than merely obliterating large dead spaces. These tailored approaches underscore the need to consider the specific anatomical and clinical circumstances of each part of the device, potentially improving outcomes in the management of complex LVAD complications. Furthermore, this case demonstrates the clinical importance of understanding the activation of the omentum upon foreign body exposure, which can enhance infection pathway obliteration. Future research should elucidate histopathological evidence and explore long-term outcomes involving larger populations to further validate these strategies and optimize management protocols for LVAD complications. Adherence to the CARE guidelines ensures that this case report meets the highest standards for clarity and completeness. The checklist is provided in the supplementary materials for reference (**Supplementary Fig. 1**).

Abbreviations

LVADs, Left ventricular assist devices; LD, latissimus dorsi; NPWT, negative pressure wound therapy.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

DS: Contributed to writing the original draft, review, and editing of the manuscript. TMa: Developed the methodology, conducted the investigation, and analyzed the data. TO: Conducted the investigation and provided supervision throughout the study. TMi: Contributed to the conceptualization of the research study. KI: Handled data curation and performed formal analysis. EF: Provided validation of the research findings. SW: Contributed to the study's conceptual framework and design and supervised the writing process. YY: Contributed to the study's conceptual framework and design, and contributed to deriving conclusions from the results. All authors contributed to editorial changes in the manuscript. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, ensuring the integrity and accuracy of the research.

Ethics Approval and Consent to Participate

This case report was exempted from ethical approval by the Institutional Review Board (IRB) of Hokkaido University Hospital, as the IRB does not require ethical approval for individual case reports. However, written informed consent was obtained from the patient for the publication of this report and any accompanying images.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.59958/hsf.7905.

References

[1] Crespo-Leiro MG, Costanzo MR, Gustafsson F, Khush KK, Macdonald PS, Potena L, *et al*. Heart transplantation: focus on donor recovery strategies, left ventricular assist devices, and novel therapies. European Heart Journal. 2022; 43: 2237–2246.

[2] Iglesias-Álvarez D, Pathania V. LVAD as a bridge to decision complicated with pump thrombosis and infection. Indian Journal of Thoracic and Cardiovascular Surgery. 2021; 37: 341–344.

[3] Long B, Robertson J, Koyfman A, Brady W. Left ventricular assist devices and their complications: A review for emergency clinicians. The American Journal of Emergency Medicine. 2019; 37: 1562–1570.

[4] Sajjadian A, Valerio IL, Acurturk O, Askari MA, Sacks J, Kormos RL, *et al*. Omental transposition flap for salvage of ventricular assist devices. Plastic and Reconstructive Surgery. 2006; 118: 919–926.

[5] Copeland H, Baran D. A persistent problem-The dreaded LVAD driveline infection. Journal of Cardiac Surgery. 2022; 37: 105–106.

[6] Cikirikcioglu M, Ponchant K, Murith N, Meyer P, Yilmaz N, Huber C. Treatment of HeartMate III-LVAD driveline infection by negative pressure wound therapy: Result of our case series. The International Journal of Artificial Organs. 2021; 44: 912–916.

[7] Clark RC, Swanson MA, Cai Y, Sarode AL, Lineberry KD, Kumar AR. Threatened Ventricular Assist Devices: Meta-analysis of Negative Pressure Therapy and Flap Reconstruction Outcomes. Plastic and Reconstructive Surgery. Global Open. 2022; 10: e4627.

[8] Takayama Y, Yokoo S, Makiguchi T, Komori T. Motor Nerve Preservation and Muscle Atrophy After Pectoralis Major Musculocutaneous Flap Surgery for Oromandibular Reconstruction. The Journal of Craniofacial Surgery. 2016; 27: 2055–2060.

[9] Seder CW, Rocco G. Chest wall reconstruction after extended resection. Journal of Thoracic Disease. 2016; 8: S863–S871.

[10] Jo GY, Ki SH. Analysis of the Chest Wall Reconstruction Methods after Malignant Tumor Resection. Archives of Plastic Surgery. 2023; 50: 10–16.

[11] Schulte-Eistrup S, Reiss N, Schmidt T, Billion M, Schmitto JD, Warnecke H. Greater Omentum Wrapping to Treat Systemic Ventricular Assist Device Infections. Operative Techniques in Thoracic and Cardiovascular Surgery. 2017; 22: 186–197.

[12] Polycarpou A, Pahwa S, Blackmon SH, Stulak JM. Novel Innovations for Ventricular Assist Device Infection. ASAIO Journal (American Society for Artificial Internal Organs: 1992). 2021; 67: e221–e223.

[13] Litbarg NO, Gudehithlu KP, Sethupathi P, Arruda JAL, Dunea G, Singh AK. Activated omentum becomes rich in factors that promote healing and tissue regeneration. Cell and Tissue Research. 2007; 328: 487–497.

[14] Sivaratnam K, Duggan JM. Left ventricular assist device infections: three case reports and a review of the literature. ASAIO Journal (American Society for Artificial Internal Organs: 1992). 2002; 48: 2–7.

[15] Lee ZH, Abdou SA, Daar DA, Anzai L, Stranix JT, Thanik V, *et al*. Comparing Outcomes for Fasciocutaneous versus Muscle Flaps in Foot and Ankle Free Flap Reconstruction. Journal of Reconstructive Microsurgery. 2019; 35: 646–651.

[16] Salgado CJ, Mardini S, Jamali AA, Ortiz J, Gonzales R, Chen HC. Muscle versus nonmuscle flaps in the reconstruction of chronic osteomyelitis defects. Plastic and Reconstructive Surgery. 2006; 118: 1401–1411.